

Original Title:
High Resolution Spectroscopy of
AGNs and GRBs

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Astrophysics

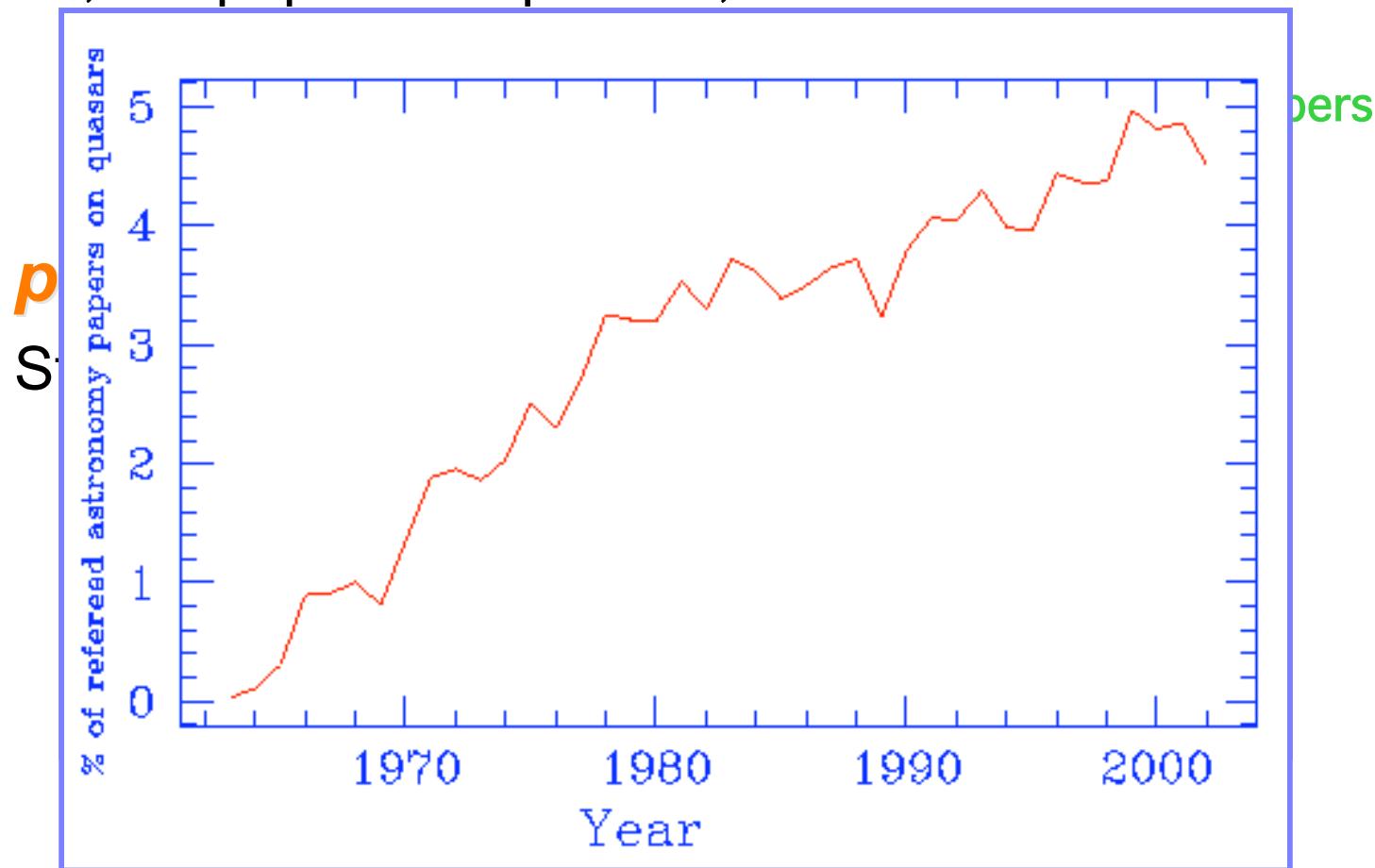
Quasar Wind Physics

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40 Years of Quasars

12,277 papers on quasars, AGN since 1963 ADS to 4/18/03



on-spherical geometry

Physical quantities for AGNs, quasars

- **Reverberation mapping:**
 - Sizes (cm)
 - Keplerian motion
 - Black hole masses
- **Polarization:**
 - Degree of flattening/non-sphericity
 - Orientation
- **Warm absorber variability**
 - A Con-X strong point

Winds from AGNs & Quasars

- Newly recognized as semi-universal
- Dynamically important $m_{\dot{m}} > \sim 0.1 m_{\dot{m}}(\text{acc})$
- Pulls together *all* atomic features in AGNs?
“Quasar Atmospheres”
- *Time variability -> physical quantities*
- Qualitative advance in understanding AGNs

AGN ‘Warm Absorbers’

- Discovered by Jules Halpern (Columbia) 1984
- Several talks here already: Kaastra, Blustin, Ogle, Kinkhabwala, Chartas
- OVII, OVIII edges dominate in ROSAT, ASCA. -
 > highly ionized ($U \sim 1$)
- Photoionized:
 - respond to continuum changes
 - But in a complicated way.
- *Chandra & XMM*: ~ 1000 km/s outflow or **wind**
- *WA have potential to deliver much physics*

Warm Absorber *Variability* gives physics

See: Mathur, Elvis & Wilkes 1995 ApJ 452, 230.

Nicastro, Fiore, Perola & Elvis 1999, ApJ 512, 184

Fully characterized plasma:

- Density n_e : recombination/ionization time lag to cont. changes
- Radial Distance, r : n_e , ionization parameter (n_{ph}/n_e), L_{cont}
- WA thickness, δr : N_H , n_e
- WA temperature, T : amplitude of response to cont. changes.
- Pressure, P : n_e , T
- Mass outflow rate, m_{dot} : n_e , velocity v (* $f_c \cos \theta$, as in binary masses)

Warm Absorber Variability physics

So far only a few examples:

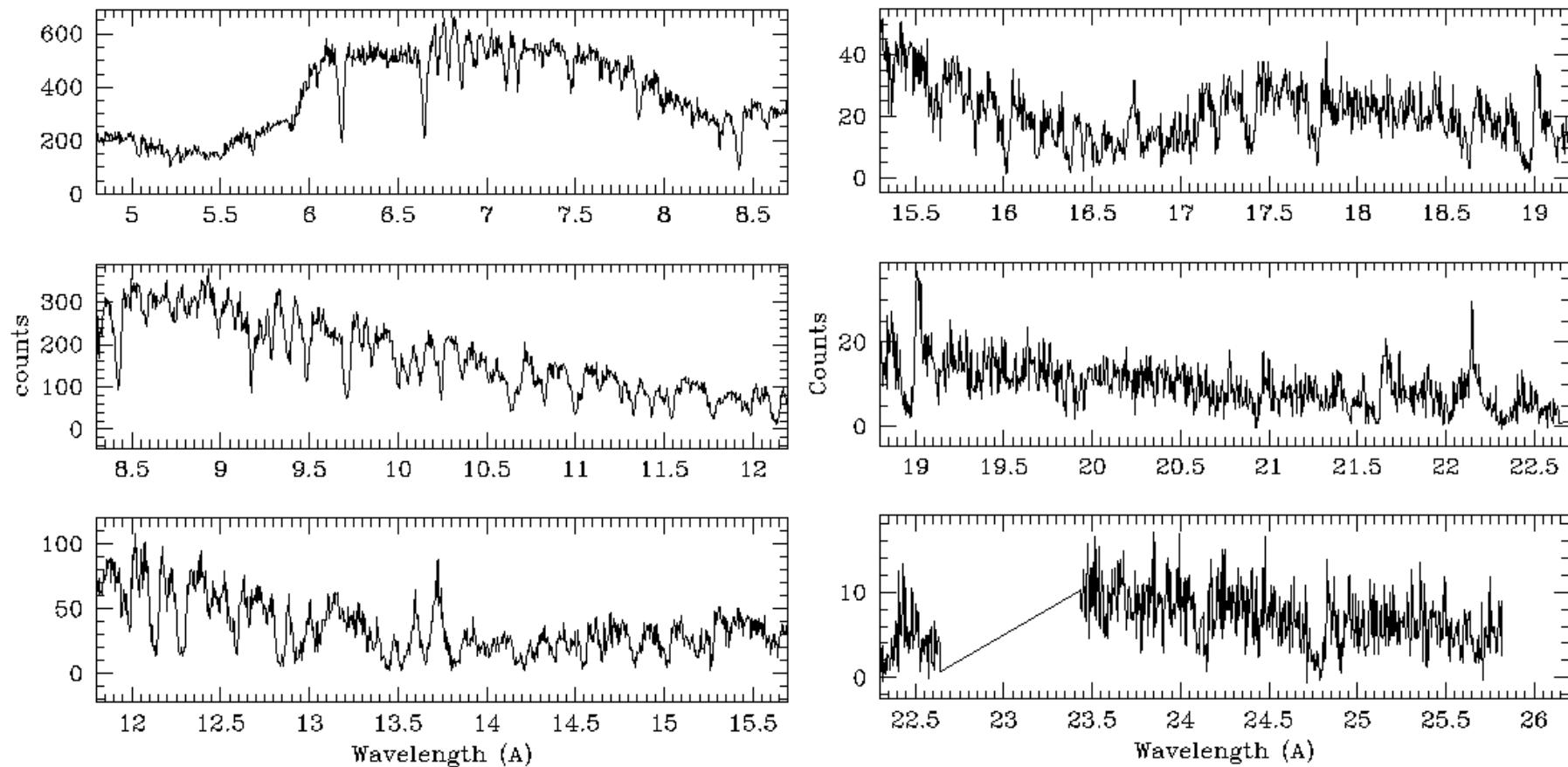
- NGC5548 (ROSAT/IUE) *Mathur, Elvis & Wilkes 1995 ApJ 452, 230.*
- NGC4051 (ROSAT) *Nicastro, Fiore, Perola & Elvis 1999, ApJ 512, 184*
- NGC3516 (HETGS, but low state) *Netzer et al. 2002 ApJ 571 256*

$$n_e \sim 10^8 \text{ cm}^{-3}, T \sim 10^6 \text{ K}, r \sim 10^{16} \text{ cm}, \delta r \sim 10^{15-16} \text{ cm}$$

- Suggestive: $P(\text{WA}) \sim P(\text{BELR})$ Turner et al. 1993, Kaastra et al. 1995, Marshall et al. 1997
- Large *statistical* uncertainties (factor 3-10)
- *Systematic* errors from simple physics:
 - ♣ 2-edge fits OVII, OVIII
 - ♣ Assumes *simple* WA to apply analysis
- *May not be the case...*

Warm Absorbers: complicated solutions

- Complex spectra – complex results
 - Chandra HETGS 850ksec spectrum of NGC 3783



Warm Absorbers: complicated solutions

- 2 physically separate absorbers [Otani et al. 1996 PASJ 48, 211 \[ASCA\]](#)
- 2 or more absorbers with arbitrary parameters (N_H , U)
- Relativistic lines [Branduardi-Raymont et al. 2001 A&A 365, L140](#)
- Dust [Lee et al. 2001 ApJLett. 554, L13](#)
- High iron abundances (>10x solar) [Blustin et al. 2002 A&A 392, 453](#)
- Large outflow velocities [McKernan et al. 2003 astro-ph/0304403](#)
- Continuous range of U [Krolik & Kriss 2001 ApJ 561, 684](#)
- No easy physics *if* many –component solutions
 - Con-X won't solve wind conditions

Warm Absorbers: a simple solution

Our* approach: first build a complete model first:

PHASE

photoionized absorber spectral engine

See poster by **Krongold Y.** et al. 2003

Includes:

- ATOMDB atomic database Smith et al. 2001 ApJ 556 L91 <http://asc.harvard.edu/atomdb/>
- UTA approximation Behar, Sako & Kahn 2001 ApJ 563, 497
- Voigt line profiles

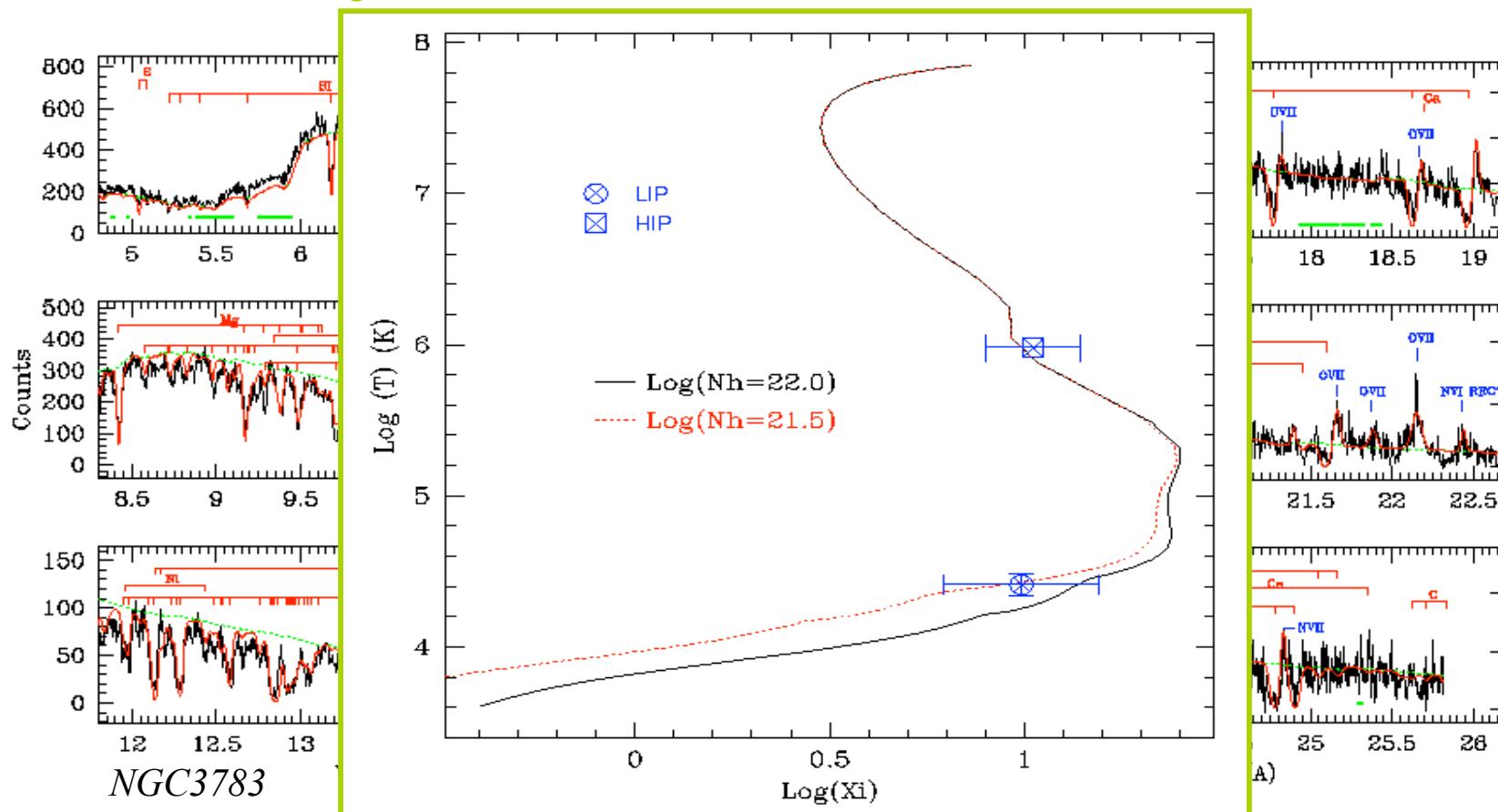
Approach:

- Global fit. Crucial for continuum level (c.f. Lyman- α forest)
- Emission/absorption mutual cancellation allowed for
- Minimum of free parameters (6)

* Krongold, Nicastro, Brickhouse, Elvis, Liedahl & Mathur 2003, ApJ *almost submitted!*

Chandra HETGS 850ksec spectrum of NGC 3783

Krongold, Nicastro, Brickhouse, Elvis, Liedahl & Mathur, 2003

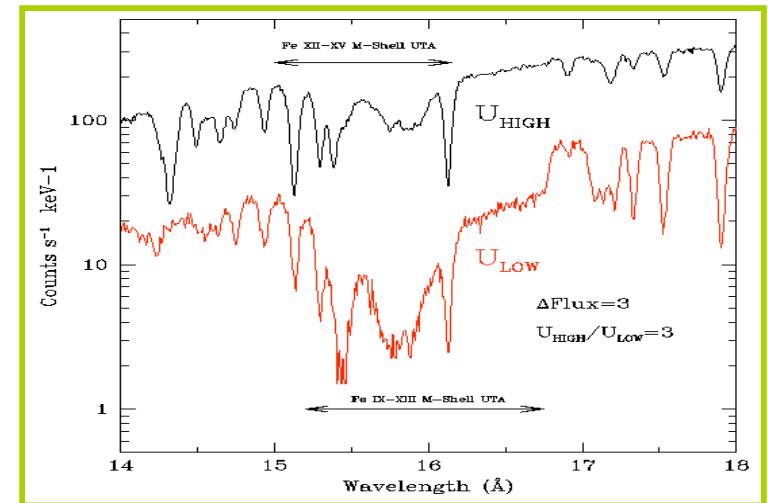
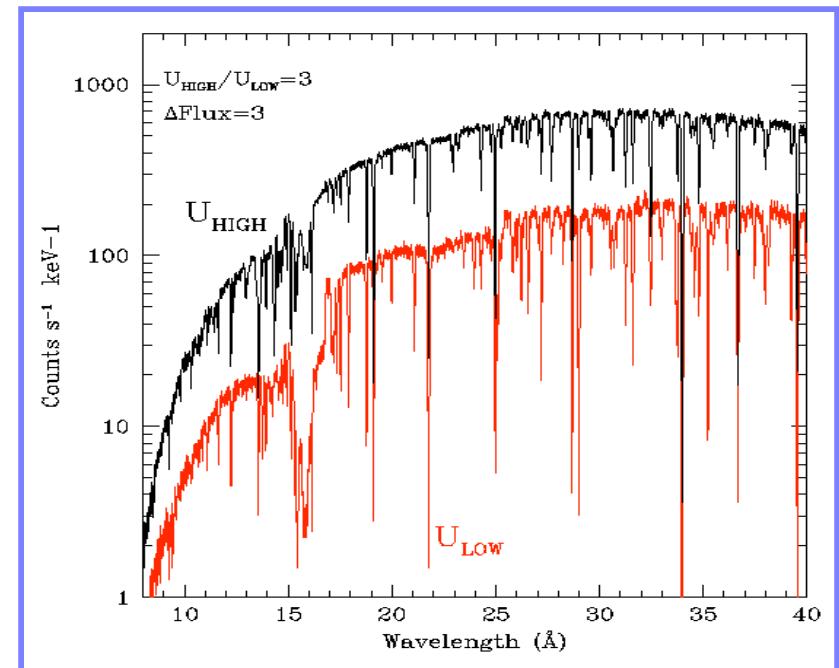


- Over 100 absorption features fitted by a 6 parameter model
- One $T \sim 10^6$ K and one $T \sim 10^4$ K, in pressure balance

2-phase gas in equilibrium

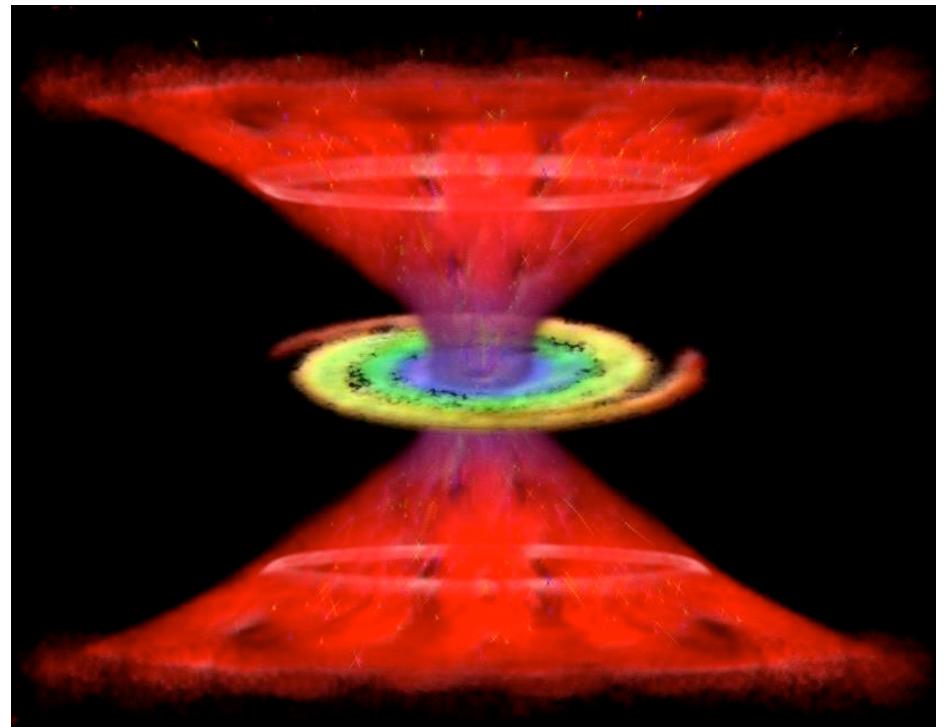
Quasar winds: prime Con-X science

- Simple 2-component solution:
-> Variability analysis will work
- Con-X area gives similar spectra in
20ksec @ ~1 mCrab
- Hence for
 $t_{\text{recomb}} > 20 \text{ ksec } (n_e < 10^8 \text{ cm}^{-3})$
Con-X will solve AGN wind physics
- Not necessarily in equilibrium at t=0
 - > need $\sim 20 \times t_{\text{recomb}}$ each.
- Few dozen AGN available
 - Needs $\sim 8 \text{ Msec}$ ($20 \text{ AGN} \times 20t_{\text{recomb}}$)
- UTA shape is a prime diagnostic
 - Broad
 - R ~ 1000 is sufficient



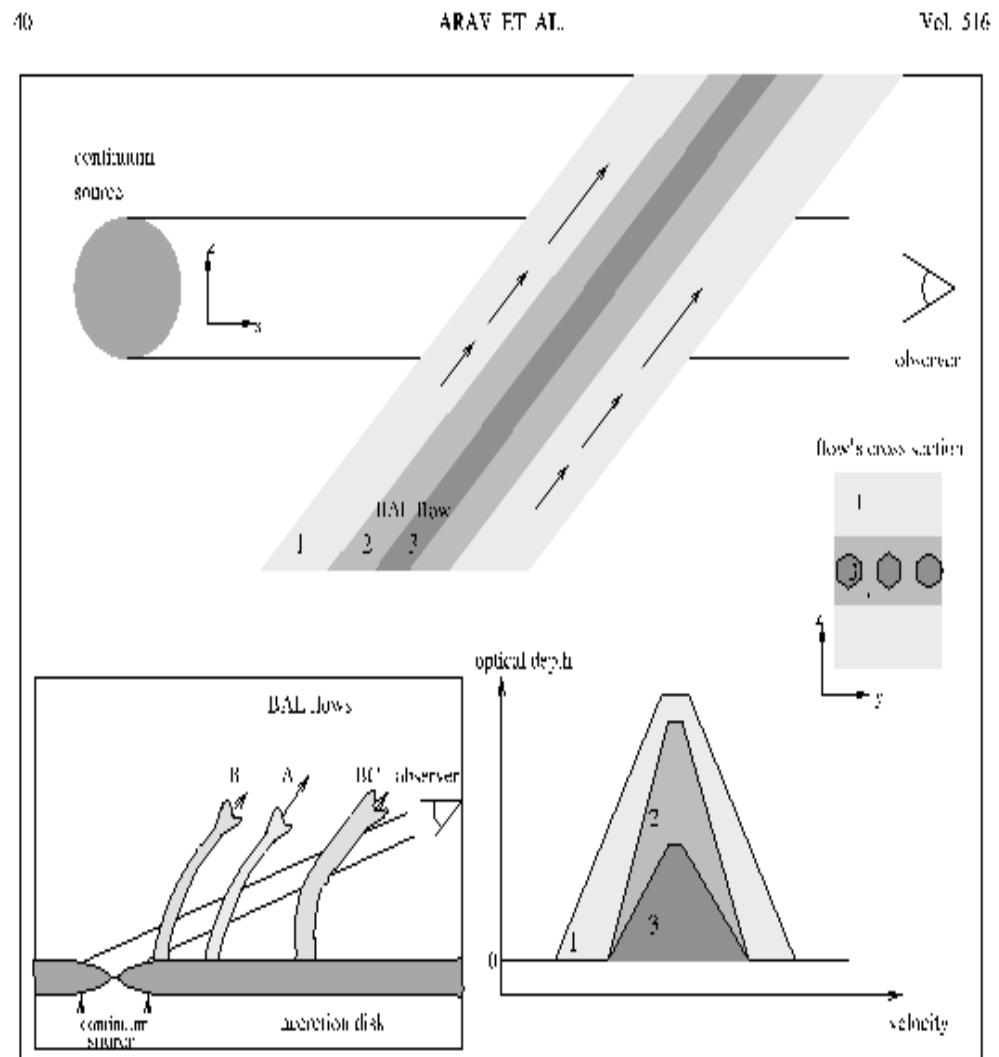
Quasar winds: prime Con-X science

- Are WA, BELR, BAL, scatterers all part of the wind?
“Quasar Atmospheres”
 - Work back to disk, continuum physics
- Mass loss rate into IGM?
 - IGM enrichment at high z ?
- Dust creation at high z ?
Elvis, Marengo & Karovska 2002 ApJLett. 566, L107.
 - Catalyzes high z star formation?



Quasar winds: more resolution

- $R=1000$ OK for this physics, but...
- $R \sim 5000$ gives *much* more
- OV, OVI \rightarrow no need for simultaneous UV spectra
- resolve multiple components down to turbulent width (~ 30 km/s)
-> does T_{thermal} reach T_{ion} ?
- Measure covering factor vs. velocity in each line
 - c.f. Gabel et al. 2002 astro-ph/0209484
 - Accelerating wind crossing line-of-sight?
Arav et al. 1999 ApJ 516, 27
 - > map continuum source?



advertisement

The Ionized Absorber in NGC 3783

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ABSTRACT

We present a self-consistent-turbulence model that utilizes the existing gas evolution code (the 2D code: *Cloudy H*) to predict the effect of MHD on the ionization and reionization processes in ionized plasmas. The model includes a total of six free parameters, and consists in a simple two-phase algorithm with differences of 3% in the ionization parameters and differences of 1% in the column density of the phases. It can reproduce more than 1000 values in the spectrum. The two absorption components appear to be in hydrostatic equilibrium with each other, and are consistent with a single outflow (750 km s⁻¹), a single turbulent velocity (300 km s⁻¹), and with solar chemical abundances. Further implications of these results are discussed.

1. The Models' Effects

With the aim of stimulating interest in ETS research and at the suggestion from our members in the spectrum of CS and X-ray sources, we have developed PEGASUS (Plasma and Gas Emission Spectroscopy) code and available software due to its limited application in ALICE/ALICE (J. L. Gammie, D. M. Hwang and J. W. Lynn, 1998, *Nature*, **392**, 71). The software serves as a driver program for the use of a control source, allowing a linking between the two kinds of gas discharges via the plasma. The parameters in the code include the ionization probability, (2), the electron temperature and density (from either collision or He II wave detection), atom density (which are set by the user), (3) and (4) the Ionized Species Energy Distribution (ISED) of the plasma species to simulate the ETS spectra emitted below the 400 nm wavelength limit in the X-ray region, provided that they are from APRIL. These correlations have been used to characterize the E-ETS method and its light ARF correlation, respectively, by solving only the self-luminescence emission which is the sum of the emission of the free particles which also can be converted into the reflected ones. Due to the E-ETS-ARF method, emission efficiency is dependent to overall ARF, because there is no loss of intensity systematically with emission decay assumption, giving interesting results as expected sometimes in the past. This is very useful for ETS spectra code, since whatever the EIT (Hg) effect involving the formation of the intensity in the excited atomic density, it has to be considered.

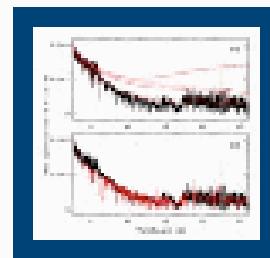


Figure 1. Mixed ML41 first-order spectrum of 74% 27M. (a) evolution of the spectrum. The three solid lines stand for the time-space transfer function measured at the various conditions indicated by the open circles further multiplied by the zero-phase transfer value. The dotted line represents the predicted power law without the contribution from the blackbody component. (b) one-phase absorption model plotted for comparison.

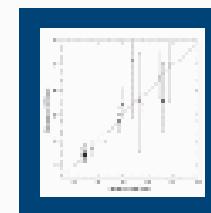


Figure 3. Measured Enzyme model predicted NADH production rates in the WCO-EBB system. A line indicates data points at the measured concentrations.

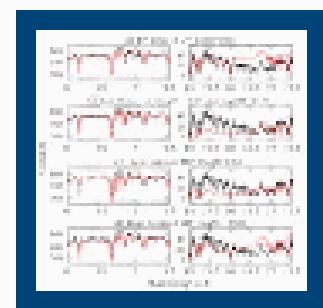


Figure 4. Different models clustering the right ventricles removed on the day before the left/right procedure. Different colors for the evaluation parameter of the two phases, the colored numbers are arbitrary.

3. Market Evaluation

The first article I'd like to apply to each of you is from the *Journal of Neuroscience*. In 2000, James and Michael Miller, at the University of Illinois at Urbana-Champaign, published a paper showing that the members of P110 $\alpha\beta$, have different roles when it comes to controlling the growth of neurons. We're not talking about their total production, small changes in the firing can produce completely different results. In other words, the total number of neurons that a particular gene controls is the same, but the way that they grow is different. This is in contrast with what we've all learned so far, which is that there's one gene that controls everything.